

# Opportunities to Reduce Energy Intensity in the Aluminum Industry



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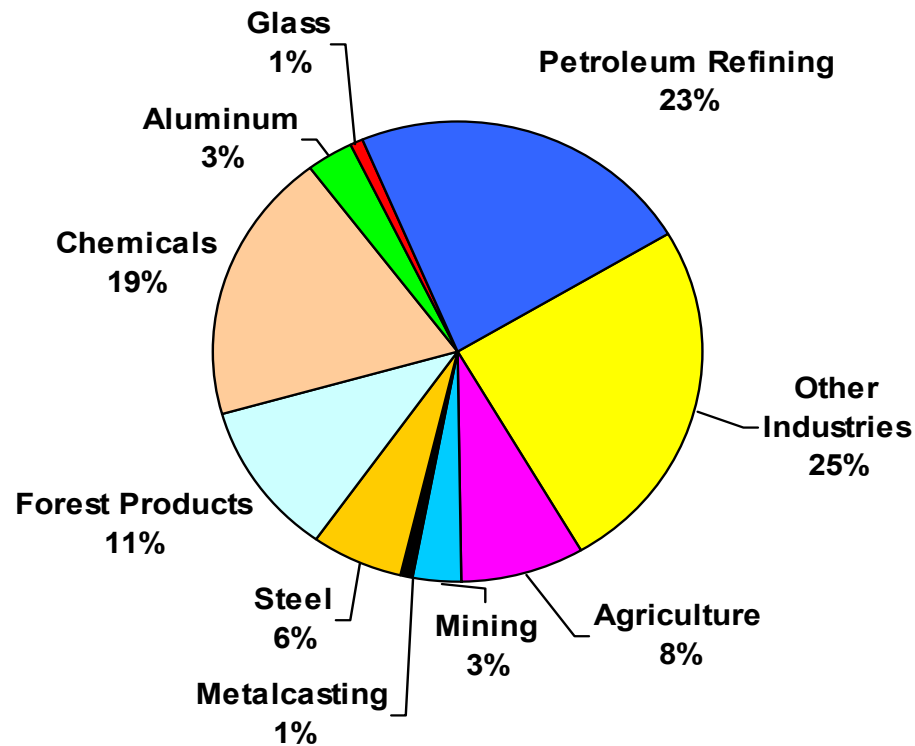
John Green, Consultant  
Presented at E-vision 2002  
Washington, DC.  
May 15<sup>th</sup>, 2002

# The Energy Picture

U.S. Energy Use is  
Split Between:

- Residential
- Transportation
- Manufacturing

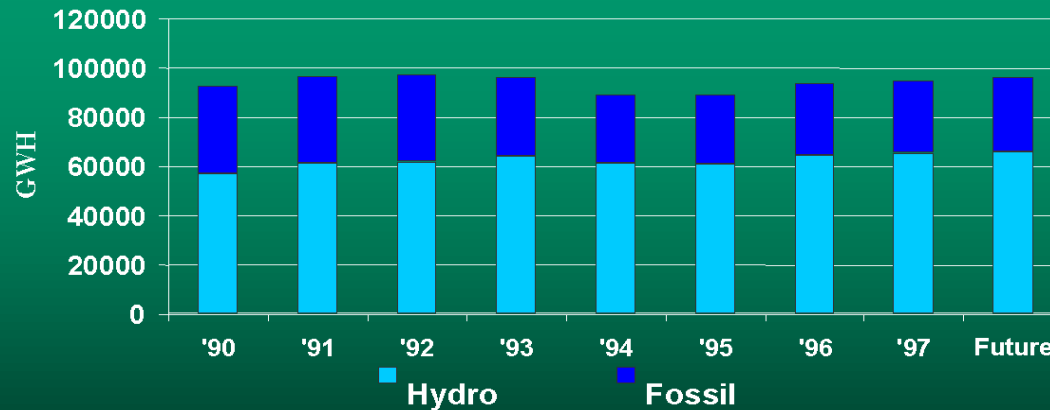
Manufacturing Component ~40 Quads



Aluminum is Small Overall User -- but with High Electrical Portion (~80%)

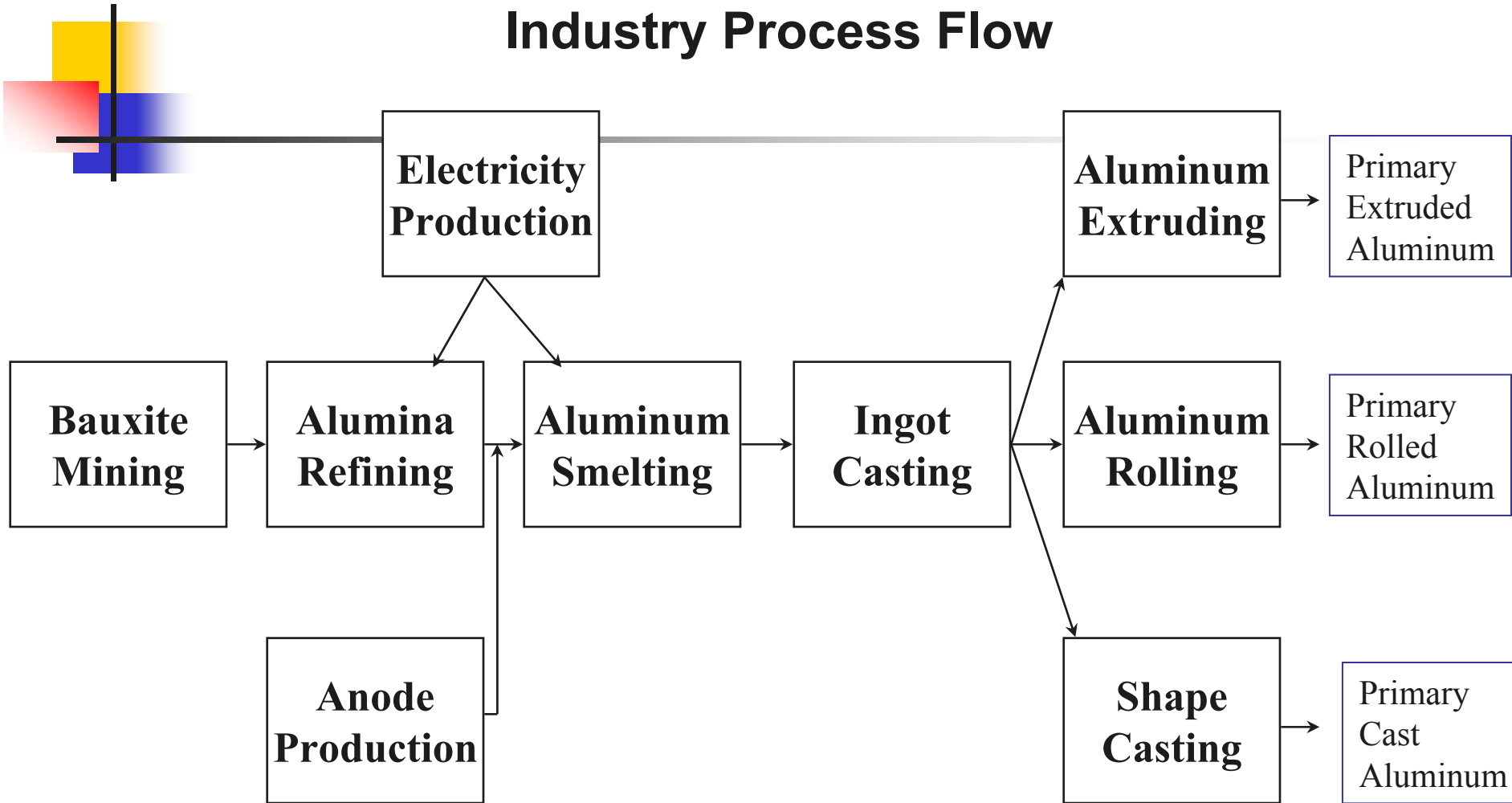
# Proportion of Renewable Energy Used In Aluminum Production

**Figure 2: Source of Electricity Supply to Aluminum Smelting**

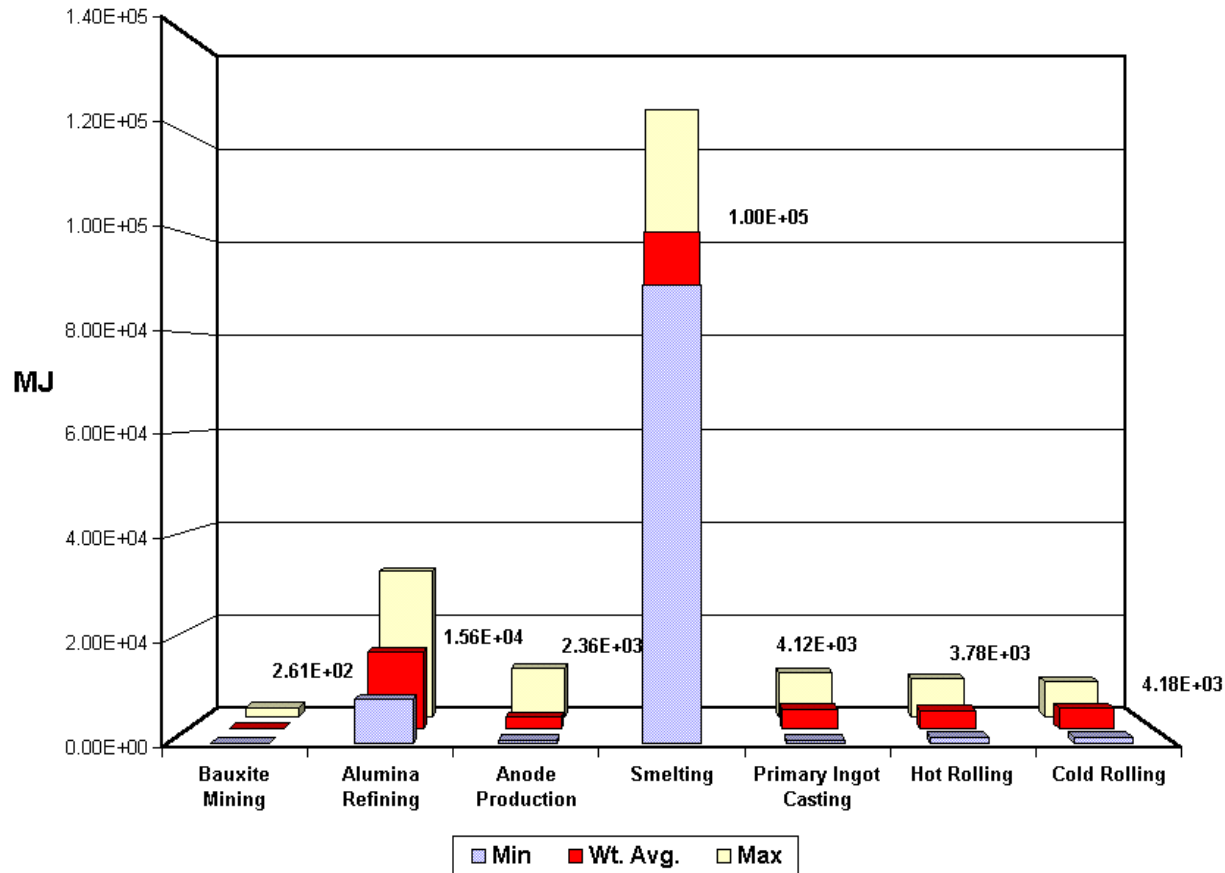


- More Than 50% of Energy is Hydropower
- Industry Produces ~34% of its Own Needs; Seeking More Energy Independence

# Industry Process Flow



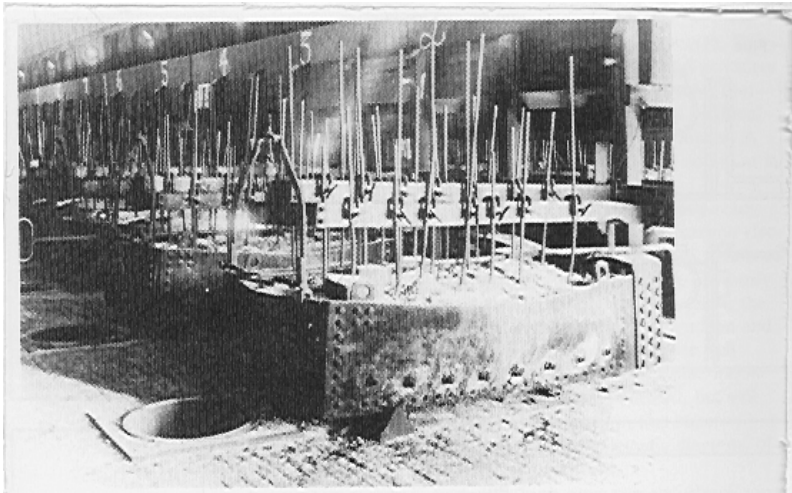
# Primary Unit Processes Energy Consumption\* per 1000 kg of Output



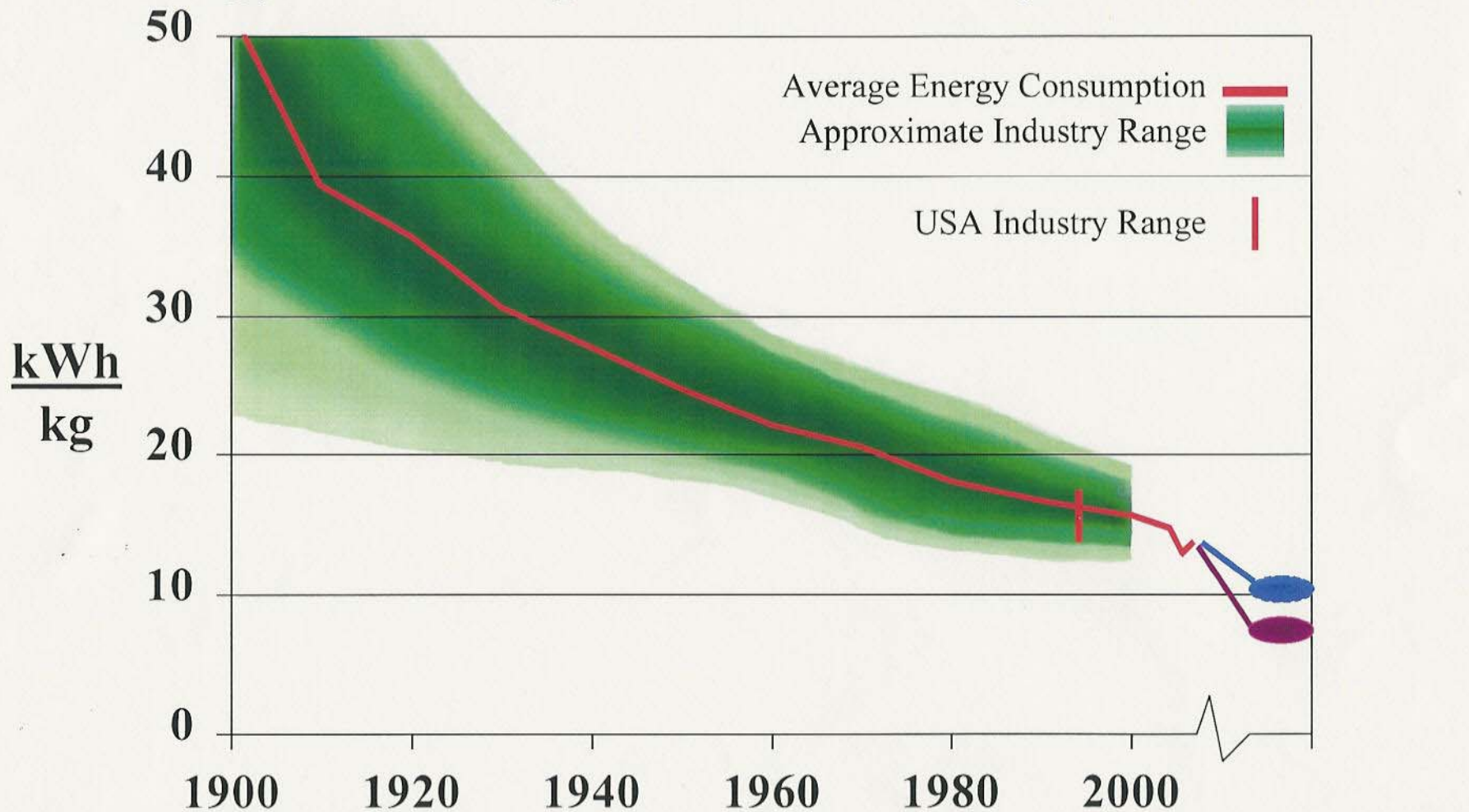
\*variation due to difference in technology is not is not accounted for

# Hall Heroult Process Changes

- Enormous Changes in Scale and Sophistication
- Additional Changes Still Possible
  - SOA Cells Achieve  $\sim 13.0$  KWh/kg Al
  - Theoretical Minimum 6.36 KWh/kg Al



# Energy Consumption - Primary Aluminum



International Aluminum Institute, 2001

R. Burkin, "Production of Aluminium and Alumina"  
 Haupin, *History of Energy Consumption by Hall-Heroult Cells*, pages 106-113,  
 in the "Hall-Heroult Centennial" book

"Life Cycle Inventory Report for the North American Aluminum Industry," The  
 Aluminum Association, Washington, DC (1998)

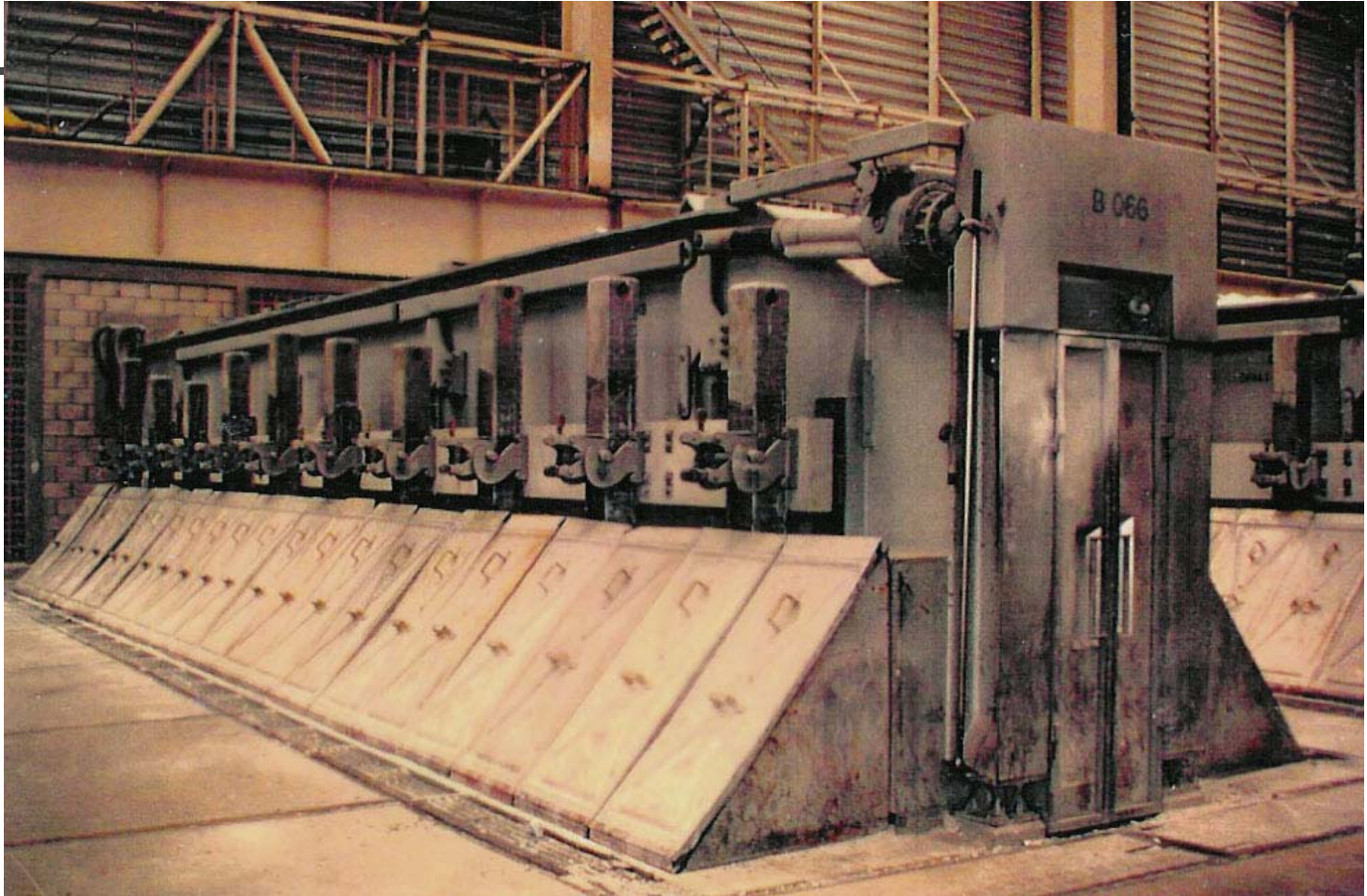


# Addressing the Energy Issue

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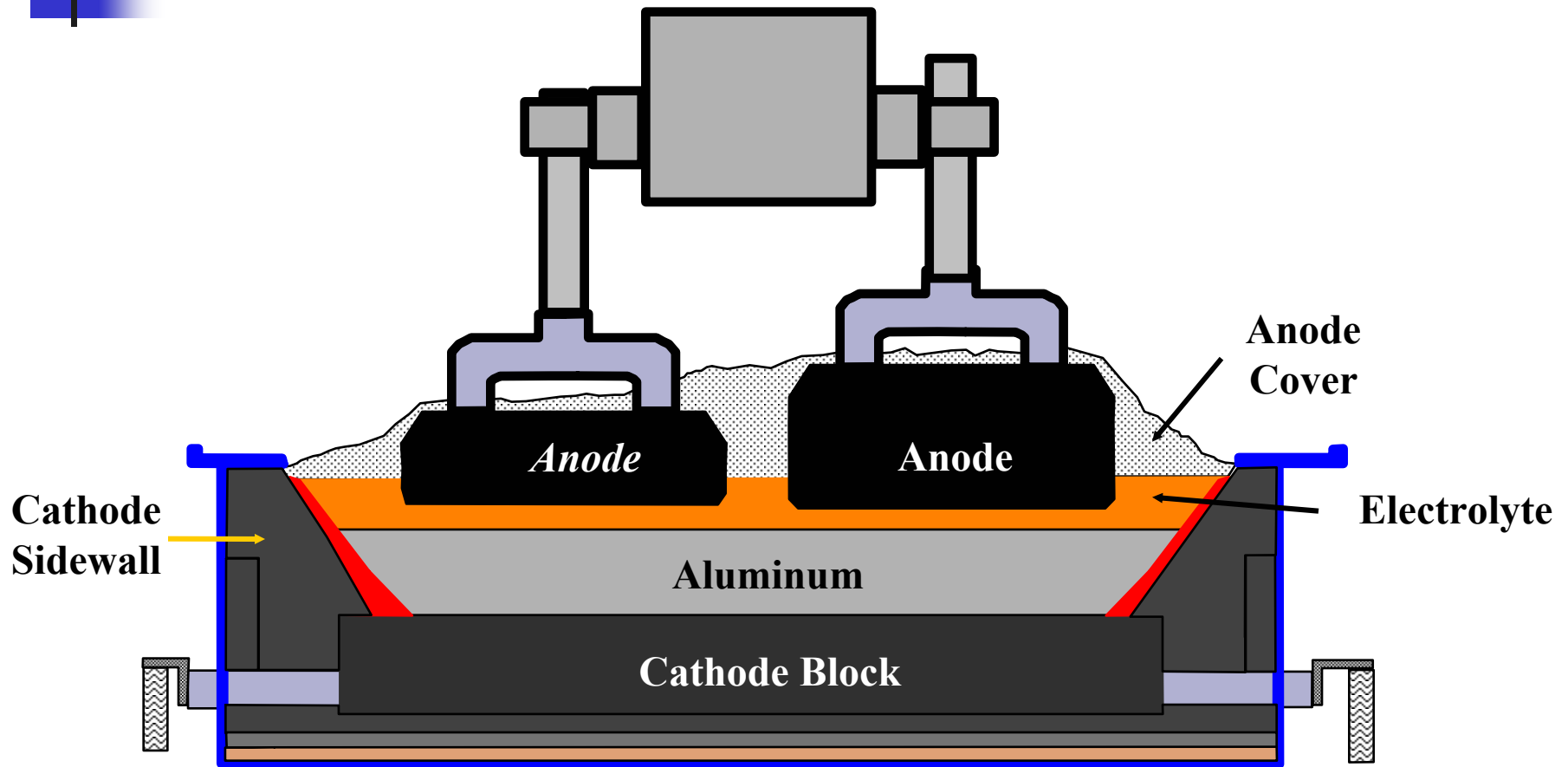
- Advanced Cells -- Wettable Cathode/Inert Anode Enable Narrower ACD  
Improved Melting and Combustion Systems
- Continuous Casting - Eliminates Rolling Process Steps
- Recycling and Scrap Sorting - Saves Energy, Improves Economics
- Sensors and Process Controls - Increases Efficiency in Many Areas

## *Aluminum Smelting*



Pechiney AP-30 Prebake Cells - 300 kA

# Aluminum Smelting



**Prebake Reduction Cell**

# Cell Technology Developments

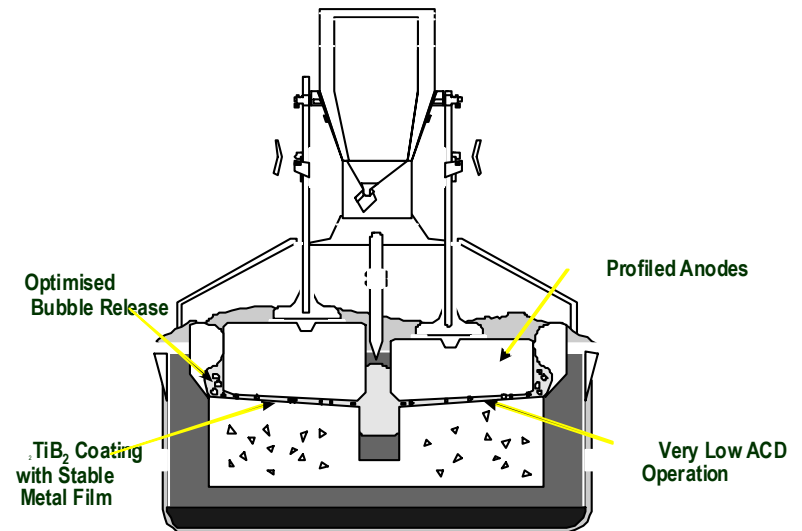
## ■ Incremental

- Higher Amperage
- Larger Anode Area
- Point Feeders
- Lower Bath Temps

## ■ Radical

- Wettable Cathode
- Inert Anode
- Energy savings up to ~25%

## Typical Drained Cathode Cell



Source: G.D. Brown, et. al., "TiB<sub>2</sub> Coated Aluminum Reduction Cells: Status and Future Direction of Coated Cells in Comalco", *Queenstown Aluminum Smelting Conference*, November 26, 1998.

## Concept of Drained Cell

# Results of Drained Cell Trials

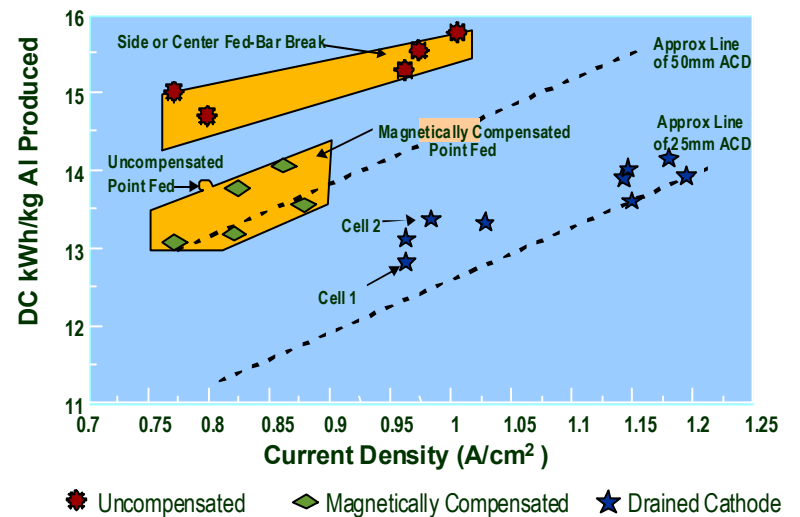
## COMALCO

- Demonstrated concept

## OPERATION

- No metal pad
- ACD ~ 2.5 cm
- ~40% Productivity Gain
- Material and Design Issues

## Drained Cell Performance



Source: G.D. Brown, et. al., "TiB<sub>2</sub> Coated Aluminum Reduction Cells: Status and Future Direction of Coated Cells in Comalco", *Queenstown Aluminum Smelting Conference*, November 26, 1998.

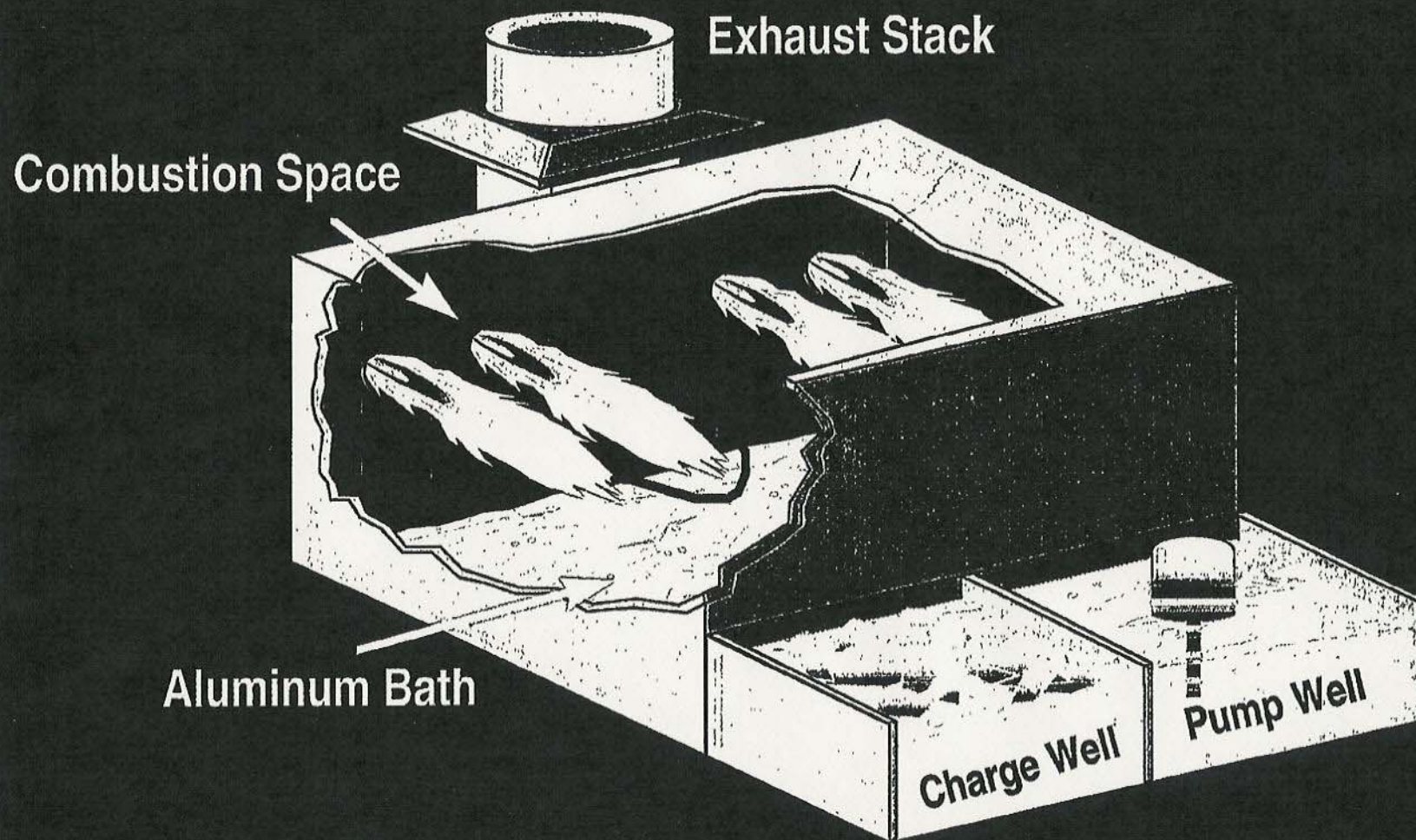


# Developing Smelter Processes

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- Vertical Multipolar Cells (Northwest Aluminum) – offers greater productivity.
- Carbothermic Reduction (Alcoa/Elkem) – minimizes electrical energy and capital requirements.
- Clay to Aluminum (Toth Aluminum Company) – reduction of  $\text{AlCl}_3$  produced from clays.

**Figure 2-1. Depiction of secondary aluminum melting in side-well reverberatory furnace**





# High Efficiency Melters

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- Oxygen-enhanced combustion (air-oxy-fuel conical combustor)—installed at Wabash Syracuse plant by Air Products.
- Low Dross Combustion System—layered flame to minimize dross formation (Gas Technology Institute).
- Reduction of melt loss through analysis and characterisation—(Secat).

# Continuous Casting

- Direct conversion of molten metal into thin strip eliminates several rolling and heating steps

- Block, Roll (Fata Hunter) and Belt (Hazelett) Casters

- 1100 and 3xxx Alloys routinely continuously cast

- Hazelett now has cast 5754, 6111 Auto Sheet



**Alcan Continuous Casting Unit**

# Aluminum Industry Status, 2000

Annual Growth 1990-2000*	Markets	%
9.8%	Transportation	32.5
0.3%	Containers & Packaging	20.4
2.6%	Building & Construction	13.1
4.8%	Consumer Durables	6.9
3.3%	Electrical	6.9
4.8%	Machinery & Equipment	6.1
1.7%	Other	2.6
0.9%	Exports	11.4
4.0%	Total Shipments	100.0
24,486 x 10 <sup>6</sup> lb.		



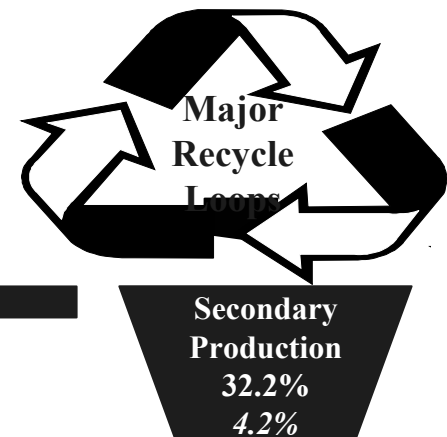
Autos ~90% capture: 12 yr. frequency



Cans ~62% capture: 8-10 weeks



Building and Construction  
~50% capture: ~ 40 years



**Total U.S. Metal Supply**  
23,586 x 10<sup>6</sup> lb.\*  
3.4% annual growth 1990-2000

**Imports**  
33.5%  
8.9%

**Primary Production**  
34.3%  
-1.0%

\*Difference between supply and shipment is due to inventory drawdown

All italicized % are for annualized growth rate over 1990-2000

# Automotive Markets

## Products Distribution

- Castings - - - 73.8%  
(~60% recycled)
- Extrusions - - 22.8%
- Rolled Sheet - 3.4%



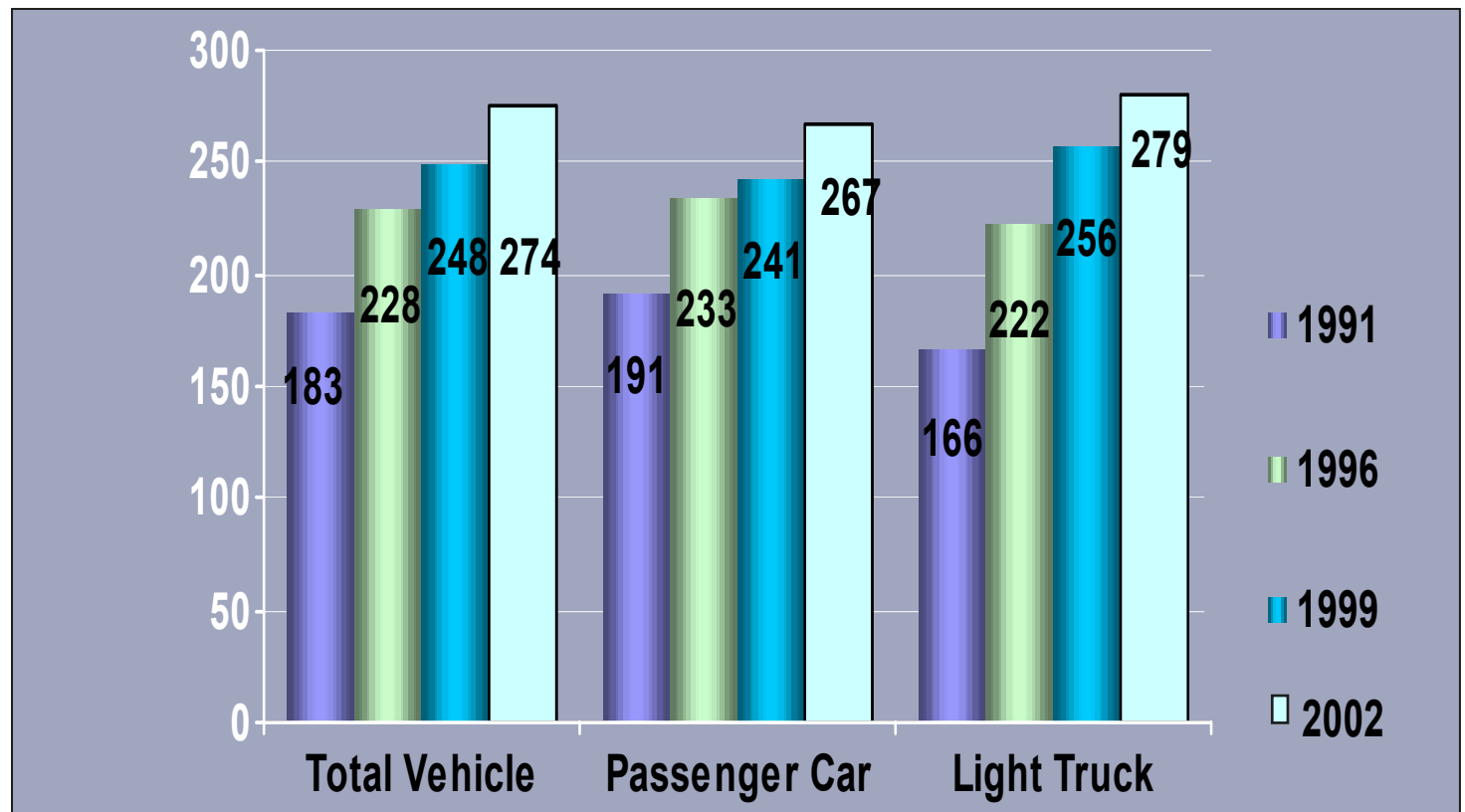
Average Use ~274lb / vehicle -- and Growing



## ***Auto & Light Truck***

Aluminum Content (lbs.) per N.A. Vehicle  
1991, 1996, 1999 and 2002

Source: Ducker Research Company



# Recycling

■ Recycling saves 95% of energy and emissions compared to extracting metal from ore

■ Economics of recycling improved by separating:

- Cast from wrought
- 5xxx from 6xxx

■ Color sorting versus Laser (LIBS) sorting

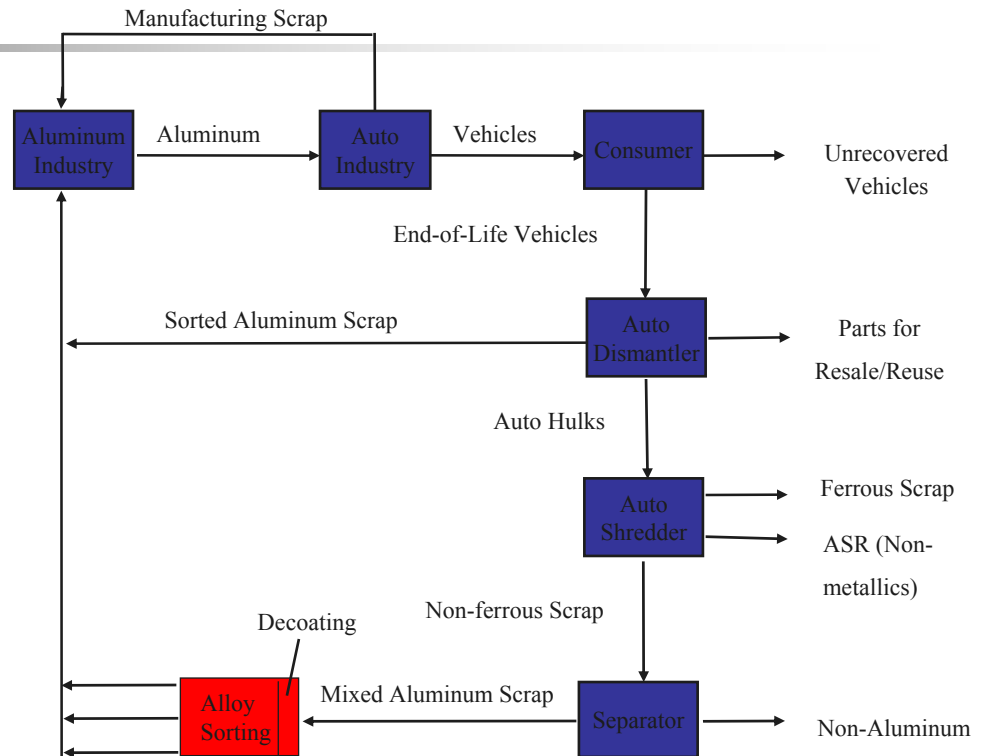


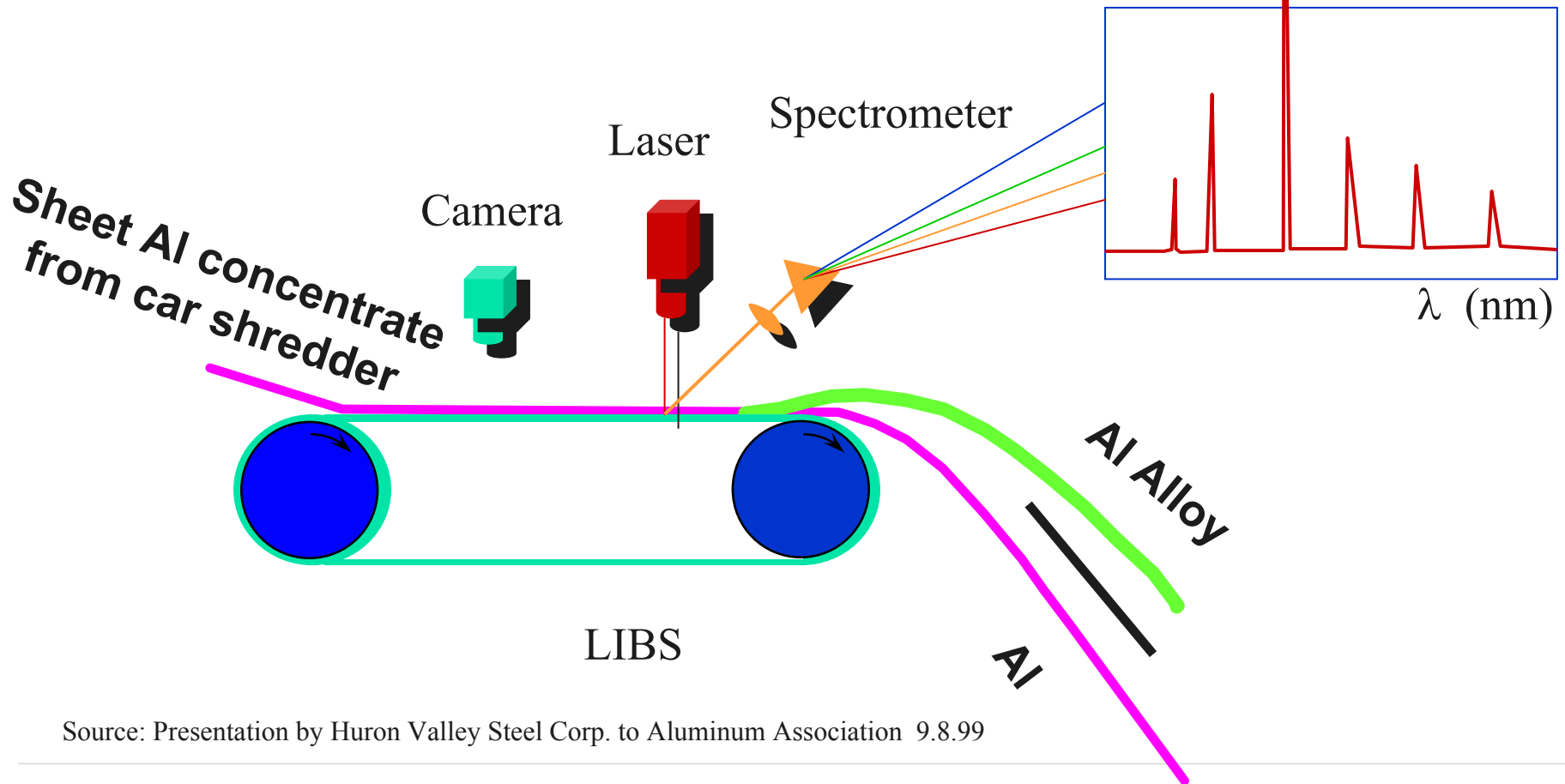
Figure 8-3. Future Aluminum Recycling Process

Source: Aluminum Industry Roadmap for the Automotive Market, publ. The Aluminum Assn.

# Alloy Sorting by Laser Induced Breakdown Spectroscopy

Technology spin off from Alcan work in early 90's

Now subject of Auto Aluminum Alliance program with Huron Valley



Source: Presentation by Huron Valley Steel Corp. to Aluminum Association 9.8.99



# Process Sensor and Controls

■ Improved sensors and controls increase productivity

■ Some examples:

- Alumina refinery sensors optimize steam, caustic use, track impurity levels; saving 10% fuel consumption (Paul K. Talley, Aluminum Today Apr. 2000, p. 34)
- Smelter sensors have reduced anode effects by ~50 %, enhanced production, reduced emissions (EPA VAIP data)
- Non-contact, multi-wave length, infrared temperature measurement of extrusion billet increases quality, reduces die wear
- Variable flow coolant valves improve shape control of rolled aluminum
- Optical sensors enable color sorting during recycling

# Aluminum Use -- Washington Monument



Replica of Aluminum  
Capstone Placed Atop  
Washington Monument  
Washington, DC - 1884



Repair of Washington  
Monument Used 40  
Miles of Aluminum  
Scaffolding - 1999